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Utilizing and developing our resources to enhance quality of life

Farm & Home RESEARCH

Volume 56 • Number 3

South Dakota State University • College of Agriculture & Biological Sciences • Agricultural Experiment Station



**SOUTH DAKOTA
CERTIFIED™ BEEF**

**SOUTH DAKOTA
SELENIUM IS
JUST RIGHT**

CONTENTS



12

3 Dean's comments

4 South Dakota Certified™ beef

8 South Dakota selenium is Just right

12 Colorful co-product of ethanol production shows promise

14 The gold is gone, the toxins remain

18 Who's that guy in the mirror?

20 Breaking into the white corn market



20



8

On the cover:

Steve Taylor, Lyman County, has turned problem into profit. Plagued by a selenium-heavy soil on parts of his farm, he had to carefully watch his horses and work a little harder to get a calf crop. But selenium toxicity in animals can be turned to healthful, and indeed necessary, nutrients in human foods, and demand from other countries for Taylor's selenium-rich wheat is expected to grow. Selenium-bearing soil in South Dakota is spotty and is found most often over marine shale deposits, see map with story. Photo is by Bob Fanning, Lyman County Extension educator.

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Dean's comments

BY GARY LEMME

Dean, College of Agriculture & Biological Sciences

It's All About PEOPLE

This is the third time that I have moved to SDSU: first as an undergraduate in 1970, 11 years later as a young plant science professor, and again this summer as dean of the College of Agriculture and Biological Sciences. I am Gary Lemme. My wife Terry and I are proud alums of the College of Agriculture and Biological Sciences (ABS). During the past 15 years that I have been gone from South Dakota, I have served in administrative positions at the University of Hawaii, University of Minnesota, and Michigan State University. I am happy to be "home" and working with the current and future leaders of South Dakota.

A hallmark of the ABS College is our faculty's commitment to students and providing them excellent educational opportunities. Learning in the ABS College occurs in classrooms, laboratories, competitive judging contests, student clubs, and research laboratories. Undergraduate education will continue to be a focus of the ABS College. Our citizens and students expect the best from our faculty. We are fortunate to have nationally recognized researchers and educators in our classrooms. They freely give of their personal and professional time because of their dedication to students and stakeholders throughout South Dakota. At ABS, **It's All About People**.

The Dakota Agriculture College was established in the winter of 1881 with the mission of educating citizens to improve South Dakota's economy and communities. In contemporary language, our mission is to enhance South Dakota's economic development and quality of life through the development and dissemination of new knowledge. The ABS College remains focused on improving people's lives through science and education. Thus, **It's All About People**.



Gary Lemme

Scientists in the ABS College conduct strategic research for an intended use. Quality science intended to meet present day challenges while providing future opportunities is our core value. Stakeholders from throughout the state have a roll in identifying research and educational priorities in a partnership-like relationship. Thus, **It's All About People**.

The most critical carriers of new knowledge across the state continue to be our Extension educators. The seamless integration of Extension and Experiment Station activities best serves the youth and adults of our state. We are not separate entities. We are committed to providing quality educational programs across the disciplines of both the ABS and Family and Consumer Sciences colleges to enhance the vitality of South Dakota communities and families. Thus, **It's All About People**.

Dr. Kevin Kephart, the director of the South Dakota Agricultural Experiment Station (AES), has been appointed as SDSU's vice president for research and dean of the Graduate School. Kevin has provided exceptional leadership during the past 7 years. I look forward to working with him in the future as he shapes SDSU's research program.

We welcome Dr. C.Y. Wang as the Interim Director of AES until a permanent replacement is identified. The search process has already begun. The trajectory of the growth in research is so strong that if we were to lose momentum now, the state could experience a costly delay in putting that science-based knowledge to work in our economy and lives. Thus, **It's All About People**.

I am proud to be a Jackrabbit and a South Dakotan. I look forward to working with you and our faculty, staff, educators, and students. The ABS College is committed to you. Remember, at the ABS College, **It's All About People**. ♦





Premium pricing for producers, premium products for consumers:

SOUTH DAKOTA CERTIFIED™ BEEF

South Dakota produces the world's best beef. That's what South Dakotans have long believed, and now the rest of the country is going to learn it.

South Dakota Certified™ beef is a new opportunity for South Dakota beef producers and processors to add value to their products. The concept was introduced in Gov. Mike Rounds' 2010 Initiative, and new legislation grants the state authority to administer the program.

Scientists at South Dakota State University are lending their expertise to the program, contributing research-based knowledge to developing specifications for beef producers and processors.

"There are over 60 branded beef programs in the U.S.," says Jafar Karim, director of the South Dakota Governor's Office of Economic Development. "We need to differentiate from the other programs. First of all, our program is based on sound science, proven techniques, and industry expertise."

It's also the first branded beef program in the country to be backed by a state government, says Eric Iversen, livestock development specialist in the South Dakota Department of

Agriculture's Division of Agricultural Development. "This is the only program that has the state standing behind it to assure accountability in its claims."

ADDED VALUE AND PREMIUM PRICING for their products are the main benefits of the program for producers and processors, says Duane Wulf, SDSU meat scientist.

"We know from consumer research that if you make a consistently high-quality product, a majority of consumers are willing to pay for it. There is also a smaller segment of consumers willing to pay for enhanced safety and source verification. All of this hopefully means that there is going to be a demand at a price that's higher than commodity beef."

Just following all the rules is no automatic guarantee of a premium for the product, but Wulf adds that the brand will be backed by marketing initiated by the state of South Dakota. The Governor's Office of Economic Development is conduct-

“... our program is based on sound science, proven techniques, and industry expertise.”

—JAFAR KARIM, DIRECTOR,
SOUTH DAKOTA OFFICE OF ECONOMIC DEVELOPMENT

ing market research and planning a marketing campaign for the brand. Gov. Rounds has also promoted the brand in interviews with national media, including radio shows and food magazines.

CONSUMER BENEFITS FROM South Dakota Certified™ beef are high quality, premium beef products.

“The vision is that it’s better than anything else you can get; it’s consistently good quality,” says Robert Maddock, SDSU meat scientist. “With the limited geographical area, we should have more control, because we don’t have the whole gamut of types, locations, climate, and genetics that other [national and regional] programs have. So we should be more consistent than other certified programs and definitely more consistent than commodity beef that doesn’t have a label.”

The South Dakota Certified™ Beef program will also provide benefits for South Dakotans in general, Karim adds. “It obviously starts with our producers and our processors, ... but over the course of time we think it’s going to blossom in opportunities not just for them, but for the Main Streets, for the retailers, grocers, and restaurateurs, to be able to market some of the best beef there is in the world.”

A MARKETING ADVISORY COMMITTEE, with Wulf and Maddock as two of its members, helped plan the program. A new Extension meat specialist position in the SDSU Animal and Range Sciences Department has been created in response to a request from Gov. Rounds that the Cooperative Extension Service play a major role in launching South Dakota Certified™. Maddock was named to that position in July 2005.

“SDSU scientists were instrumental in the development of the program,” Karim says. “As we move into implementation, their primary role is going to be education and training of processors, as well as monitoring and sampling product quality and tracking results over time to measure continuous improvement.”

To provide scientific basis for program requirements, Wulf conducted a comprehensive literature review of research studies that evaluated meat quality.

“In the 85 different studies I examined, there were 26 different factors that affect eating quality of beef. I ranked those according to the effect that they had,” Wulf says. Factors included, for example, animal age, gender, and breed, as well as a number of processing techniques.

SDSU Extension teamed up with the South Dakota Department of Agriculture to offer a series of one-stop workshops across the state in the summer of 2005 for producers who wanted to learn more about the program, says Julie Walker, SDSU area beef specialist.

By August, 15 workshops had been held throughout the state to educate producers on the requirements of the program, the process of becoming a licensed producer, and the procedure to enroll cattle in the program. A total of 258 participants attended, adds Iversen.

Prior to becoming licensed, he says, producers must have completed the South Dakota Beef Quality Assurance/Critical Management Plan Program (BQA/CMP) training offered by the Extension Service and be certified and have an official USDA Premises number. Twenty-five producers had submitted application forms by August.

“For the first training we targeted some processors who are leaders in the state,” Maddock adds. “These are people we know who are interested in the program and who are running really good businesses. We wanted to get some input from them about the training.” Iversen expects the program to grow as weaning time approaches, since this is the point at which animals must be enrolled.

“Also, as we move toward a National Animal Identification System, the need to begin the traceback of food animals will become more important. Resumption of trade with Japan and South Korea will also provide incentives for producers to participate in source and age verified beef programs,” he says.

Maddock and Wulf will also be responsible for monitoring compliance with the South Dakota Certified™ beef program.

“We’re going to randomly select South Dakota Certified™ beef from restaurants and grocery stores and inspect it. If something is out of compliance, we’ll work with that producer or processor to improve the quality of the beef,” Wulf says.

“... if you make a consistently high-quality product, a majority of consumers are willing to pay for it ... [and] willing to pay for enhanced safety and source verification.”

—DUANE WULF,
SDSU MEAT SCIENTIST

THE SLOGAN, “South Dakota Certified™ beef. The world’s best beef,” is just about on the money, says Maddock.

“Our clean environment, the lack of Brahman influence, and larger herd size all lead to higher quality and more consistency.

“We don’t have any Brahman influenced cattle, because we don’t need heat tolerance. In the South, there’s a lot of Brahman influenced breeds, and those cattle produce beef that’s tougher,” Maddock says. “We tend to have wide open spaces and a lot of rangeland, so our cattle are healthier. We also have bigger herds. In the East, cattle producers tend to have small herds of 30-50 head, while in South Dakota we have herds with 200-500 head. That allows for more consistency in genetics and quality.”

Cody Wright, SDSU Extension beef specialist, points out that South Dakota calves have long been known as some of the best and are selling very well at cattle auctions.

“Over time our producers have done a nice job of selecting proper genetics and putting emphasis on traits that cattle feeders are looking for, such as growth, efficiency, and muscling. There’s definitely a high demand for their calf crop.

Additionally, the steers that have been enrolled in the SDSU Calf Value Discovery program have proven to marble well and, with few exceptions, be quite tender,” Wright says.

THE FIRST SOUTH DAKOTA CERTIFIED™ BEEF products are likely to hit the stores in late summer or early fall. The program is going to start out small, but the vision is to expand to other domestic and international markets, says Karim.

“We envision a modest start. Our processing capacity will grow as new markets for South Dakota Certified™ beef are discovered. Cattle producers will realize a benefit from selling cattle as South Dakota Certified Enrolled Cattle™ even if they aren’t processed into South Dakota Certified™ beef.”

The collaboration of state government, SDSU, producers, and processors has far-reaching advantages, Karim says.

“It’s not just a government program, it’s not just a private industry program, it’s an educational program. It’s going to provide opportunities for young people who are coming through the system at SDSU to be able to stay in South Dakota and work with this program or with a private processor,”

Karim says. ♦ —*Marianne Stein*

SOUTH DAKOTA CERTIFIED™ Beef program specifications

SOUTH DAKOTA CERTIFIED™ Beef program specifications:
(This is not a complete list of all specifications. For more information, look online at www.southdakotacertifiedbeef.com)

Producer specifications:


- Cattle must be born, raised, and finished in South Dakota.
- Brahman-influenced breeds are not eligible.
- Producers must be Beef Quality Assurance/Critical Management Program certified.
- Cattle must be fed a ration of at least 50% corn and/or distillers grain for a minimum of 100 days.
- Cattle must never be fed ruminant derived tissues or animal or food wastes.
- Cattle must be less than 24 months of age at the time of slaughter.

- Cattle must be fitted with an electronic identification ear tag, allowing for complete age and source verification.
- Producers must be educated on raising cattle in a humane and environmentally cautious manner.

Processor specifications:

- Only South Dakota Certified™ enrolled cattle are eligible for inclusion in the brand.
- Branded products must be kept separate from other products during harvesting and processing.
- Processors must be able to trace South Dakota Certified™ products from live animal to finished product.
- Processors must use at least one of five pre-approved quality enhancement techniques.





This selenium is too low, this selenium is too high,
**SOUTH DAKOTA SELENIUM IS
JUST RIGHT**

Lyman County farmer-rancher Steve Taylor knew the selenium-rich soils that underlie some of his fields and pastures could be a problem. Through the years he's occasionally had horses start to go lame and observed cows that have had trouble conceiving.

Those are symptoms of what scientists know now is selenium toxicity, first documented in 1860 in what would become South Dakota. The surgeon general of the U.S. Cavalry described the complaint in horses and cattle at Fort Randall, less than 100 miles as the crow flies from Taylor's ranch. Under Fort Randall are the same West River soils, formed from the parent materials soil scientists describe as Pierre shales and Niobrara marls, as on Taylor's farm.

But while too much selenium can be toxic to both animals and humans, some is necessary, and a growing body of research suggests selenium delivers real health benefits. That explains why, starting in the 1990s, Taylor began to reap some profits—literally—from those selenium-rich soils.

BUYERS FROM GERMANY AND AUSTRIA were glad to pay premium prices for wheat grown in Taylor's fields because it is considerably higher in selenium than ordinary wheat. The Europeans market it to health-conscious consumers in their home countries who are interested in selenium because of its role as an anti-oxidant that may have cancer-fighting properties.

"A lot of places in the world are low in selenium," Taylor explains. "There's a demand and I think there's a need for it."

Studies investigating the various ways selenium intake is related to human health are going forward in various universities. They have shown selenium can reduce the risk of heart disease by protecting against arterial deposits and helping regulate blood pressure. Other studies have explored the activity of selenium on the tumor-suppressing gene p53.

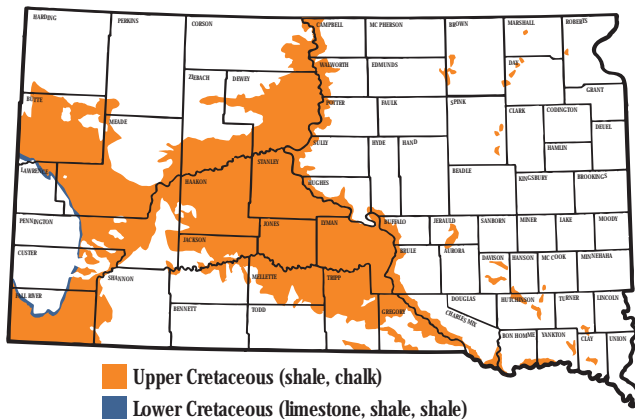
Selenium is found in nuts, vegetables, and whole grains, and wheat is thought to be the most efficient of the common cereal crops in accumulating selenium. So, as more becomes

"A lot of places in the world are low in selenium. There's a demand and I think there's a need for it."

—STEVE TAYLOR,
LYMAN COUNTY WHEAT GROWER

“Mother Nature has provided a potential marketing advantage for South Dakota if we can add that nutrition benefit to our high quality wheat.”

—RANDY ENGLUND, EXECUTIVE DIRECTOR,
SOUTH DAKOTA WHEAT COMMISSION



Location of marine shale deposits in South Dakota. Selenium-bearing soils form from these deposits.

known about selenium’s helpful effects when included in the right amounts in the diet, demand for selenium-rich wheat—such as that which grows on parts of Steve Taylor’s farm—is likely to increase.

Randy Englund, executive director of the South Dakota Wheat Commission, says South Dakota has long been known for top quality spring wheat and winter wheat. The possibility of being able to sell selenium-enhanced wheat from some parts of South Dakota would give buyers from selenium-deficient countries additional incentive to buy wheat from South Dakota, he says.

“Mother Nature has provided a potential marketing advantage for South Dakota if we can add that nutritional benefit to our high quality wheat.”

MOTHER NATURE IS ALSO HOLDING TIGHT to her secrets. There are many questions about what happens in the plant and in the soil to make plants take in selenium. Furthermore, selenium is not uniformly distributed across fields.

“A lot of people don’t understand that. They think if you’ve got a 100-acre field, you’re going to get 100 acres of wheat high in selenium. That hasn’t been my experience,” Taylor says.

After an earlier SDSU research project did a grid sampling to check the selenium levels of wheat in the dough stage on his land, Taylor was able to roughly map out selenium “hotspots”

in his fields so that he could harvest those locations separately. Within a 300-acre field, Taylor calculates that he has about 10 acres quite high in selenium, and an additional 30 acres that are “fairly high.”

But Taylor still notes that the wheat harvested off those selenium-rich parcels will vary in selenium content, depending on the growing season. Taylor’s own experience in marketing selenium-rich wheat to European buyers tells him that from year to year, the same half-section of land will produce lots of wheat with selenium contents varying from 9 parts per million, 10-, 12-, and up to 20 parts per million.

Jim Doolittle, SDSU soil scientist, says research is beginning to look at the difference that agronomic practices can make in determining how much selenium plants take in. For instance, research at some universities suggests elevated sulfur content in the soil somehow inhibits selenium uptake.

Doolittle notes that phosphorus may have the opposite effect and actually increase selenium uptake. That was the focus of a greenhouse study Doolittle undertook with Sang-Hun Lee, graduate student, funded in part by the South Dakota Wheat Commission.

“We know that phosphorus plays a role. What’s currently thought is that it helps by competing for the adsorption sites on the soil,” Doolittle says. “Our premise was that phosphorus would displace some of that selenium on those binding sites, making it more available for plant uptake.”

Lee says that explains why selenium uptake by plants is not predictable based on total soil selenium concentration: Uptake is highly related to selenium’s association with other constituents in the soil. To complicate things even more, previous research has separated soil selenium into five fractions, two of which are unavailable to plants, two of which are available, and one which is conditionally available to plants.

Since the SDSU experiment called for fertilizing beyond what is needed for producing the target wheat yield or wheat



The selenium project of Jim Doolittle and Sang-Hun Lee is advancing from greenhouse to sites along the Missouri River, with check plots back in Brookings. Results will better show how agronomic practices and environment affect the uptake of selenium in the plants.

goal that is usual in South Dakota, Sang Hun first did a greenhouse study to find if there was a toxicity or inhibitory response in the wheat when phosphorus was increased up to 1,000 parts per million. There was no detrimental effect from high levels of phosphorus, but yields did plateau after the initial response.

In the actual selenium study, Doolittle and Lee blended the selenium soil with perlite—a necessary step because seleniferous soils are fine-textured and easily become waterlogged—and then grew two spring wheat varieties (Oxen and Granger) and two winter wheat varieties (Arapahoe and Wendy). Phosphorus fertilizer was applied at three different levels: 0, 100, and 250 milligrams kg-1.

They found what they expected: Phosphorus fertilization increased the total amount of absorbed selenium in the grain and stem tissue of all wheat varieties tested.

The experiment showed, in addition, that only one of the selenium soil fractions changed significantly. What is called “ligand exchangeable” selenium significantly decreased as phosphorus applications increased.

That makes this selenium fraction in the soil the one that can be most readily incorporated into wheat if the soil conditions are favorable for it.

THE PROJECT IS STEPPING OUT of the greenhouse into “the real world.”

Doolittle is planning a follow-up, outdoor study in selenium-rich soils along the west side of the Missouri River in South Dakota, with a replication on non-seleniferous soils on the SDSU campus in Brookings as a control. Two to three other sites will be on seleniferous West River soils.

With the roots of the plants able to explore greater volumes of selenium-rich earth, Doolittle says, the study will give a clearer picture of the difference that agronomic factors make in selenium uptake.

“We can produce wheat on seleniferous soils that’s about 2 parts per million selenium. We’re hoping that with the selenium-enriched grain that we want to produce, we’re going to be in the area of maybe doubling that—4 or 5 parts per million.

“Doing the calculations with a 5 parts per million wheat, I believe a person can get anti-cancer benefits from two slices of bread made from that wheat.”

Doolittle says selenium questions that still remain to be answered include the difference in selenium uptake due to the depth of the available selenium in the soil profile, rainfall during the growing season, or wheat variety. Wheat breeders think there may be varietal differences, he says.

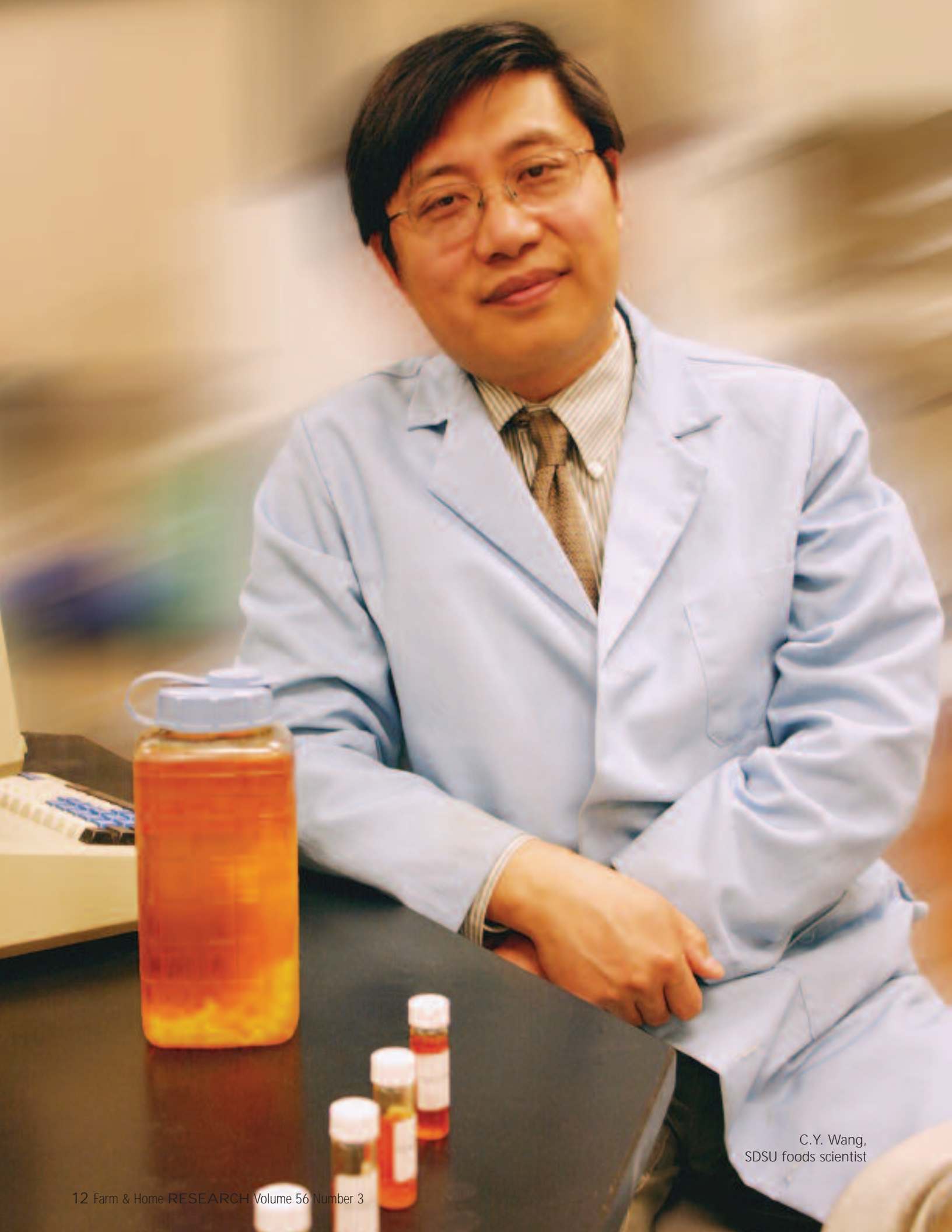
An unrelated issue, Doolittle says, is the need for mapping of seleniferous soils so that growers know where they’re located.

“Producers would like to know which of their fields have a potential to produce these selenium-enriched grains. We know in general terms where that parent material is. But it’s still on a field-by-field basis where a soil high enough in selenium is.”

Addressing at least some of those issues, the South Dakota Wheat Commission is putting \$85,000 toward a broad-based selenium research project at SDSU in budget year 2006. Planned as a 3-year project, the work would include the variability in locations where selenium is available and conditionally available in selected selenium-rich fields. Also to be investigated are differences in selenium uptake in selected spring and winter wheat varieties as influenced by weather conditions and soil selenium.

Additional questions may lead to answers that determine the distribution of selenium within the kernel of wheat after milling; the bioactive form of selenium in selected wheat varieties; the total antioxidant activity of selected wheat varieties; and the antioxidant activity from selenium conjugates. ♦

—Lance Nixon



C.Y. Wang,
SDSU foods scientist

COLORFUL CO-PRODUCT OF ETHANOL PRODUCTION SHOWS PROMISE FUELING CARS, LIVESTOCK, AND HUMANS

America's "amber waves of grain" are taking on new meaning at South Dakota State University.

A deep, dark amber is the color of the oil that SDSU food scientists have isolated from plain, sawdust-colored dried distillers grains, the co-product left over after ethanol plants take the starch from corn to make ethanol.

Ethanol is a gasoline additive. Dried distillers grains, or DDG, is best known as an ingredient in livestock diets. But new SDSU research is looking at how DDG can be refined further to yield other ingredients important to industry—oils, for example.

"We wanted, first, to find out whether it was feasible to get the oil out or not, and then also to find out the quality of the oil. Can we get the oil, and is it any good?" says C.Y. Wang, head of SDSU's Department of Nutrition, Food Science, and Hospitality in the College of Family and Consumer Sciences.

Wang says scientists were concerned that the heat processing that the DDG went through in making ethanol could have hurt the quality of the oil extracted from DDG.

"So far, we've found out that this oil is usable even for edible applications. And not only useful – it may be unique."

WHAT'S UNIQUE IS THE REDDISH-GOLD COLOR, for one thing. It took SDSU scientists by surprise.

"We should have predicted that, but our eyes were on other phytochemicals," Wang says. He explained that the color is due to the fact that the oil is rich in carotenoids—carotene or carotene-like compounds.

"Carotene is actually a precursor of Vitamin A. The body can take those compounds and make Vitamin A. Vitamin A has a lot of functions, in vision health, in skin health, and in other areas. This is not only a color issue, it is also a nutrition issue."

Corn is high in carotenoids, but ordinary corn oil is not. Wang explains that the usual way the food-processing industry produces corn oil is through a wet milling process that uses the corn germ. The part of the grain containing the carotene is the

endosperm, not the germ. That's why DDG, which retains the endosperm, may be used to produce oil high in carotenoids with potential health benefits.

SDSU researchers are hoping the oil will be high in two other compounds, called phytosterols and tocopherols. Phytosterols are forms of plant cholesterol and have been shown to be very effective in lowering cholesterol levels in humans, Wang says. Tocopherols are a group of antioxidant compounds associated with Vitamin E. Their possible health benefits include preventing heart disease.

"Antioxidants can prevent oxidation of blood lipids. When you hear about LDL cholesterol, it's often called 'bad cholesterol.' But oxidized LDL cholesterol is even worse," Wang says. "So if you have something that can prevent the oxidation of those lipoproteins, the LDLs, you actually reduce the risk of those lipoproteins forming plaque in the blood vessels."

THE DDG OIL DOES HAVE ONE DRAWBACK as far as human health is concerned, Wang cautions: It has high free fatty acids.

"That can simply be taken care of in the refining process. You just have a little bit higher refining loss."

Wang says DDG is about 10% oil. In comparison, soybeans yield about 20% oil in processing. Oil content of 10% may be high enough to be profitable, he says, especially if there are niches for the oil because of its potential health benefits.

Corn probably has only 3 to 4% oil content to start with, Wang says, but the process of making ethanol removes the starch so that the oil content increases in the distillers grain that remains.

Wang adds that DDG oil also can be used to make biodiesel, in which case its fatty acid content would not be an issue.

The South Dakota Corn Utilization Council and USDA helped fund the research for its potential benefits to corn producers and their industry. ♦ —Lance Nixon



Carrie Werkmeister, SDSU
student in plant science

GRIFFITH STUDENT WORKS ON PASSIVATION OF WASTE ROCK

THE GOLD IS GONE, THE TOXINS REMAIN

When the Gilt Edge gold mine south of Deadwood in the Black Hills was abandoned several years ago, it was an environmental disaster waiting to happen. Around the 258-acre mine were open pits and waste rock dumps, filled with huge amounts of acid-generating waste rock leaching heavy metals into local streams and potentially threatening aquifers in the Black Hills area.

In 2000, the Environmental Protection Agency (EPA) declared the mine a Superfund site, a designation that indicates land contaminated by hazardous waste. Since then, the EPA and the South Dakota Department of Natural Resources (DNR) have worked together to clean up the area and keep the toxic materials under control.

Jim Doolittle, Tom Schumacher, and Doug Malo, South Dakota State University plant science professors, are assisting with the project by providing scientific expertise and conducting research on plant growth viability and long-term effectiveness of a waste rock treatment process.

Carrie Werkmeister, plant science student at SDSU from Armour, is conducting studies on the durability of a new waste rock treatment method. Werkmeister received a Griffith undergraduate research award from the SDSU College of Agriculture and Biological Sciences to work on the project in the summer of 2005.

"We're examining a new process called passivation of waste rock. We apply a coating of potassium permanganate to the waste rock and test it to see if it holds up to South Dakota conditions," Werkmeister says.

Acid-generating waste rock is generated by pyrite ("fool's gold"), which contains iron sulfide. It is not a problem as long as the rock is left underground. When, however, it is exposed by mining to oxygen and water, the iron sulfide oxidizes and produces sulfuric acid, characterized by very low pH and high acidity. This acidic water leaches the rock and minerals, releasing high levels of nitrates and sulfates, as well as heavy metals such as arsenic, cadmium, copper, and zinc into the environment.

"About 75 million gallons a year of water is coming into the site, mostly from the surface water inflows, but also from the subsurface, and that turns into acid, heavy metal-contaminated water," says Ken Wangerud, EPA project manager of the Superfund Remedial Program.

"The objectives of the treatment studies are to see if there is a way to treat the source rock so that contact waters do not form leachates contaminated with acid and metal, and that the treatment is not compromised by weather and plant growth processes," Wangerud says.

"If that water isn't contained, captured, and treated, eventually it would just run off the site and go down to Strawberry Creek and Bear Butte Creek and head toward Sturgis."

“There are lots of mines that have this sulfite material and often it is just piled up; it just sits there and not much grows on it. So this method has potential for some far-reaching benefits if the cost is kept minimal.”

—DOUG MALO,
SDSU PLANT SCIENTIST



Gilt Edge gold mine Superfund site

A WASTEWATER TREATMENT FACILITY that collects the water and cleans it before it is released into the environment has been set up by the DENR and the EPA.

“The number one goal is to prevent acid water from getting into the streams and into the aquifer system. The temporary way is to use wastewater treatment, which is very expensive, so the EPA wants to put in a more permanent solution,” Schumacher says.

“The way to keep the rock from generating sulfuric acid is to keep air and water away from it.”

It may not be possible to completely eliminate wastewater from the site, but it can be greatly reduced if the acid-generating rock is contained, he adds.

One of the significant components of the mine, an 80-acre site called the Ruby Gulch Waste Rock Repository, which was a depository for the acid rock, has already been reclaimed with the help of the SDSU researchers. The rock in the Ruby Gulch depository was covered with several layers of materials, including an 80-mm textured material; a drain net; an 18-inch drain layer of rock; and finally a layer of subsoil and topsoil. The area must be constantly monitored to ensure that conditions aren't changing.

The EPA is hoping to find a simpler and more affordable way to reclaim the rest of the area, and that's where Werkmeister's research comes into the picture.

“The SDSU scientists are studying innovative technologies that may be potentially used at the mine site for final clean-up,” says Mark Lawrensen, DENR environmental senior scientist. “SDSU's research will clarify and define the technology that's being proposed at the site, so with their help we can decide if this will be a practical technology to clean up the site in the end.”

Passivation of waste rock is a recently developed method that primarily has been studied at the University of Nevada. The passivation process involves treating the rock with a chemical compound called potassium permanganate. The resulting coating of manganese oxide seals the sulfide particles, keeping oxygen and water away from it and thus eliminating the acid-generating conditions.

Werkmeister is conducting two studies—one to find if the coating will hold up under South Dakota weather, specifically freezing and thawing, and the second to monitor the effects of plant roots on the coating. Acid-generating rock coated with potassium permanganate is compared to rock that has not been treated.

In the freeze-thaw study, rocks are chilled for 12 hours to a temperature of at least 23°F and thawed for 12 hours to a temperature of at least 40°F in a continuous freeze-thaw cycle. After every 15 cycles, the pots are leached with reverse osmosis water and the leachate is tested for pH, electrical conductivity (EC), and sulfates.

Every 30 days, stability of the rock coating is tested with hydrogen peroxide, an oxidizing agent that causes rapid change. “If the coating is cracked or has broken, the peroxide will get into the rock and it will start to oxidize and form sulfuric acid. The pH will drop and the electrical conductivity will go up and we can pick that up,” Malo says.

“If that water isn’t contained, captured, and treated, eventually it would just run off the site and go down to Strawberry Creek and Bear Butte Creek and head toward Sturgis.”

—KEN WANGERUD, EPA PROJECT MANAGER,
SUPERFUND REMEDIAL PROGRAM

Werkmeister’s other study addresses whether plant roots—fragile but, under the “right” conditions, just about irrepressible in their growth—might affect the stability of the coating. Treated and non-treated samples of rock are mixed with topsoil, and a PVC drainpipe is placed in each container to collect leachate. Plants are grown on half of the treatment units, while the other half has no plants. The study uses forage sorghum, spring wheat, and forage peas, which are rapid-growing plants that produce lots of roots.

The experimental pots are leached monthly with reverse osmosis water and the leachates collected and tested for pH, EC, and sulfates. Soil from the units is also tested for pH, EC, sulfates, and passivation stability.

SO FAR, RESULTS LOOK VERY PROMISING. The coating is holding up in both studies, and no leaching of acid has occurred from any of the treated samples. Werkmeister’s research wraps up in January 2006.

If the results continue to be positive, potassium permanganate coating could be applied to the remaining area of the Gilt Edge Mine. First, a cost-benefit analysis has to be conducted, and efficient ways to apply the coating to a large area need to be developed. Engineering research at the University of Nevada is addressing application issues, but no solution has been found yet.

The passivation method would turn the rock into inert material, which does not add anything to the soil but doesn’t cause any damage either, Malo says. Treated rock could simply be covered with a layer of topsoil, and the area could be used for recreational purposes, he says.

Eventually the goal is to reclaim the entire area and turn it into usable land. One option would be to create a golf course. Other possibilities would be growing some type of berries or vineyard.

If the passivation method proves successful, it potentially could be used in mines all over the world.

“This situation is not unusual,” Malo says. “There are lots of mines that have this sulfite material and often it is just piled up; it just sits there and not much grows on it. So this method has potential for some far-reaching benefits if the cost is kept minimal.”

Werkmeister graduates in December 2005, and she plans to pursue a master’s degree in plant science. The Gilt Edge Mine work has given her a head start.



Tom Schumacher, Carrie Werkmeister, and Jim Doolittle, SDSU plant scientists, visit with Glen Miller, University of Nevada-Reno, second from right. His university is conducting engineering research into application of the passification procedure.

“Carrie is doing an excellent job with this research,” Doolittle says. “She is near the end of her senior year, but the project she is working on would be equivalent to a master’s student project. She’s a self-starter, she takes a lot of initiative, and she has made this project her own. She always provides ideas and thinks about different ways. If she hits a problem, she doesn’t just come back to the team with the problem, she’s got potential solutions that we can discuss.”

Werkmeister’s research projects receive funding from the EPA through the South Dakota DENR and from the SDSU Agricultural Experiment Station. ♦ —*Marianne Stein*



WHO'S THAT GUY IN THE MIRROR?

A rancher's adversaries during drought go beyond climate—they include that guy in the mirror.

That's one point South Dakota State University range scientists raised recently after examining some of the data about the 2002 drought in South Dakota. Alexander "Sandy" Smart and Roger Gates considered some possible barriers to good drought management in cooperation with Barry Dunn, former Extension range livestock production specialist and now with the King Ranch Institute for Ranch Management.

One potential problem, the three researchers say, is ranchers' own "mental models"—their deeply held assumptions or generalizations that influence their views or actions.

"Do ranchers view their grasslands or their cows as their basic ranch factory? Is their mental model of a ranch production system based on cattle or based on grass?" Smart asks.

A GLANCE AT DATA FROM THE DROUGHT YEAR of 2002 suggests that for many producers, the mental model is based on cattle.

The scientists point out that cow numbers in South Dakota declined by a mere 6% from January 2002 to January 2003, despite massive, widespread drought that slashed forage

“Do ranchers view their grasslands or their cows as their basic ranch factory? Is their mental model of a ranch production system based on cattle or based on grass?”

—SANDY SMART,
SDSU RANGE SCIENTIST

production by 50% in many areas. In other words, forced to choose in a drought year between preserving a cow herd or preserving the quality of rangeland, many operators chose to preserve cows.

“The tension is between paying this month’s bills and having a long-term goal to maintain or improve the resource as opposed to exploiting it,” Gates says.

“The long-term view would see grass as the factory, and cattle as simply the means to add value to grass by converting it to meat,” he adds.

Smart says research at the SDSU Cottonwood Range and Livestock Experiment Station shows that pastures that had been heavily stocked for 15 years produced only 58% as much vegetation growth as those that had been lightly stocked. Moderately grazed pastures produced 72% as much as those that had been lightly stocked.

Gates adds that heavier stocking rates also shift the plant community to shorter, more grazing-resistant species such as blue grama and buffalograss that are less productive than the midgrasses.

“Heavily grazed pastures suffer much more in drought than lightly or moderately grazed pastures,” Gates says.

In lightly stocked pastures, SDSU data show that spring droughts reduced annual forage yield by 21%. That compares to a reduction of 27% in moderately grazed pastures, and a decrease of 34% in heavily grazed pastures.

EXPERIENCE ALSO CONTRIBUTED to how ranchers responded to the 2002 drought, the scientists say. Gates points out that before 2002, favorable spring growing conditions had occurred for 7 years straight in western South Dakota.

Especially for young ranchers, that string of good years may have helped form misperceptions of how severe West River drought could be.

Smart adds that recent climate trends may skew a rancher’s perception of the long-term climate patterns of the Plains. He notes that a rancher who grew up during the 1960s in western South Dakota would have experienced six spring droughts in the next 40 years. But a rancher growing up in the same location in the 1920s would have experienced 10 spring droughts, and three of those lasted for 2 or more years.

The recent decades may have made ranchers unaware that historic weather patterns have been more severe. ♦

—Lance Nixon

SIDE BAR

Ranchers’ mental models and learning are not the only barriers to successful drought management. SDSU range scientists Sandy Smart and Roger Gates and their King Ranch colleague Barry Dunn observed at least three others: financial considerations, government policy, and scale.

Financial considerations: Beef-cow numbers have risen steadily from 1920 to 2004 in the Plains states, although grazing acres have stayed about the same.

Gates, Dunn, and Smart believe that indicates a shift in inventory from yearlings to cows, which leaves ranchers less flexibility. In previous decades, ranchers could use yearling cattle to harvest excess forage in years when it was available, and sell off those yearlings in years when forage was tight.

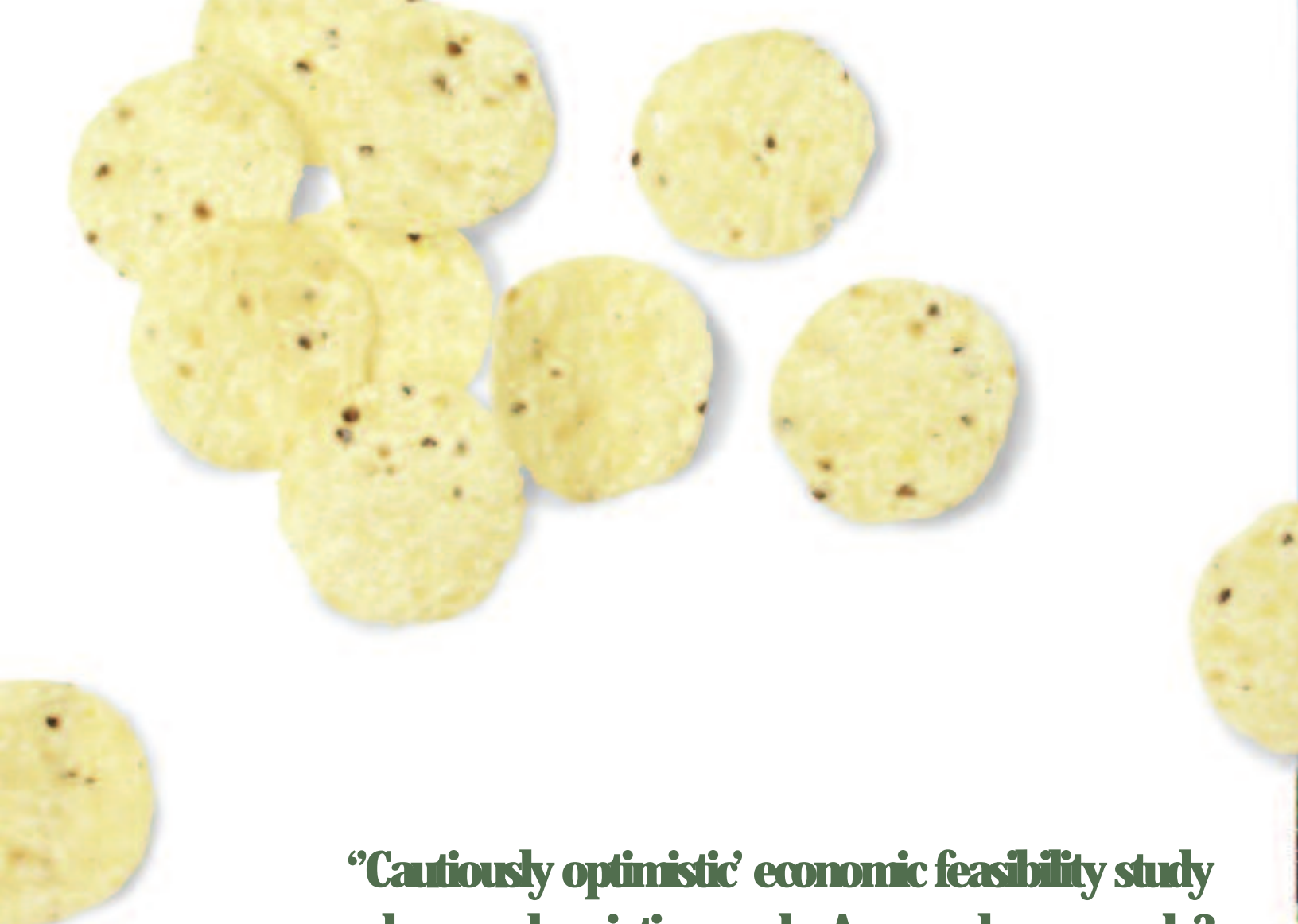
Dunn’s studies suggest calving dates in South Dakota are now approximately 60 days earlier in the year than in past decades. Earlier

calving decreases the supply of yearling cattle available for grazing, since today’s ranchers would likely consider the typical November-weaned calf too heavy to put on grass the following May.

In addition, a rancher who makes a wise decision to de-stock during a drought year can actually see his net income and tax liability increase.

Government policies: Federal drought aid may have an unintended consequence, in that it can encourage overuse of already stressed rangeland by encouraging cattle producers to hold livestock during drought rather than sell them.

Scale: Ranchers respond to drought based partly on the duration, severity, and extent of it. They’re less likely to de-stock—the most important decision that affects the recovery of their rangeland—if they perceive the drought to be limited in scale.



“Cautiously optimistic’ economic feasibility study done and varieties ready. Are producers ready?”

BREAKING INTO THE WHITE CORN MARKET

Tonya Hansen remembers growing up in a South Dakota farm family where potato chips were standard snack items but corn chips were more exotic—the sort of thing you might get on rare, special occasions but wouldn’t find on the shopping list.

Years later, the former South Dakota State University economics research associate suggests that Americans’ food choices are changing—to the benefit of the corn food industry.

“In many of today’s families, you’ll still find potato chips. But you’ll also find corn chips with salsa or cheese dip showing up on their tables,” Hansen says.

Hansen cites recent Nielsen consumer research that says 76% of all U.S. households now regularly purchase

tortilla chips, compared to 89% that frequently buy potato chips.

That trend was behind the South Dakota Corn Utilization Council’s decision to fund a preliminary feasibility study by Hansen and Evert Van der Sluis, SDSU associate professor of economics. The study was part of a larger research project on value-added uses of corn and dry mill co-products involving an SDSU multidisciplinary team including William Gibbons



Tonya Hansen, former SDSU
economics research associate



“... if you want to be competitive in the corn food product industry in the long term, it’s essential to penetrate the food service sector. One cannot simply focus on the retail sector.”

—TONYA HANSEN,
FORMER SDSU ECONOMICS RESEARCH ASSOCIATE

and Thomas West, microbiologists; James Julson and Kasiviswanath Muthukumarappan, biosystems engineers; and Padu Krishnan and C.Y. Wang, foods scientists. The corn council was interested in the market implications for corn-based food production in South Dakota, and the research was designed to help South Dakota corn producers in deciding whether investing in a corn milling facility in South Dakota is financially viable.

The findings? In a nutshell, Hansen and Van der Sluis are “cautiously optimistic” that South Dakota corn growers can benefit from consumer trends toward eating more corn and white corn food products. They see potential opportunities for South Dakota corn producers willing to organize themselves to further investigate the feasibility of processing and marketing white corn products.

PER CAPITA U.S. CONSUMPTION of corn flour has leaped by 150% since 1970, a growth rate roughly five times that of wheat flour consumption, which grew by 31%, Hansen notes.

Americans’ fondness for some Mexican-style foods such as tortillas and tortilla chips is partly responsible. Such foods fit well with consumers’ increasing demand for convenience foods, both at the retail and food service levels.

“Americans consumed 84 billion tortillas in the year 2000. That represents 305 tortillas consumed per person per year, or nearly one tortilla consumed per person per day,” Hansen says.

There are many reasons for the trend, she continues. Mexican-style fast-food restaurants are popular; children learn to like products such as tacos and tortillas in school lunch programs and ask for them at home; and many corn-based food

products store somewhat better than bread. In addition, foods eaten with corn-based snack foods—for example, corn chips and salsa—are often viewed as healthier choices when compared to alternatives such as potato chips and chip dip.

Hansen finds it especially significant that corn foods are becoming staples in schools and elderly eating programs.

“Because we’re seeing more of these products entering institutional markets and becoming a part of meals away from home, if you want to be competitive in the corn food product industry in the long term, it’s essential to penetrate the food service sector. One cannot simply focus on the retail sector.”

Hansen adds that although such products are becoming more and more mainstream, a part of tapping the corn food market must involve selling to Hispanics, the fastest-growing U.S. population segment.

But South Dakota is not in a good position to tap that market.

“Probably the largest concentrated Hispanic population closest to South Dakota would be in Chicago. There are quite a few firms in Illinois and Indiana already in place to serve that population,” Hansen says.

WHITE CORN IS PREFERRED TO YELLOW for making tortillas, tortilla chips, and corn chips. Hansen says. Growth in the market for such foods may spur a shift toward more acres of white instead of yellow corn.

White corn production represents only about 1% of the corn produced and used for food, feed, and industrial purposes in the U.S. each year. However, it makes up about 40% of the total food corn acres in the U.S., according to 2002 statistics.

Buyers have paid premiums for white corn in recent years. But Hansen cautions that those premiums, currently 10 to 25



Dawn Gustafson, SDSU research associate, and Zeno Wicks III, SDSU corn breeder, have selected white corn hybrids adapted to South Dakota conditions.

cents per bushel, have declined as supplies increased to meet demand. That suggests white corn marketing contracts may be increasingly important to producers who grow white corn.

Hansen says the U.S. Feed Grains Council estimated that U.S. domestic demand for white corn is 50 million bushels per year. About 400,000 acres of white corn must be planted to meet that demand—an acreage that the U.S. has exceeded since 1997 but that has not expanded significantly in recent years.

“After 1999, by and large, production has hovered at about 900,000 acres of white corn in the U.S.,” Hansen says. “That led us to investigate why, if there appear to be opportunities for growth in this market, why are we hovering at 900,000 acres?”

Hansen believes the answer is that the international market, while providing an outlet for U.S.-grown white corn that exceeds U.S. milling needs, is an uncertain one. U.S. producers’ ability to sell to some regions of the globe depends in some years on what happens with the crop in other major white corn producing nations such as Mexico and South Africa.

Since U.S. corn mills are running at nearly 100% capacity, expanding processing above current levels would require opening new domestic milling facilities or processing the grain abroad.

SOUTH DAKOTA WOULD BE A LATECOMER in growing and processing white corn and would come up against old players in a crowded market.

That doesn’t automatically mean South Dakota producers couldn’t get into the corn food market, Hansen says. It only means they ought to study the issues thoroughly before they move in that direction.

She adds that if South Dakota producers begin producing white corn in any quantity, it’s very likely that some processing would also need to take place in the state, since production and processing often occur in the same geographic area.

“It’s cheaper to transport the flour than it is to transport the corn,” Hansen says. “Then final processing of the flour into the food products takes place near population centers because that’s where the largest consumer base sits.”

If South Dakota producers ever decide to enter white corn production or processing, a key part of the work has already been done for them.

Professor Zeno Wicks III, an SDSU corn breeder, says he and Dawn Gustafson, SDSU research associate, have been at work on white corn hybrids adapted to area growing conditions for several years. The South Dakota Corn Utilization Council helps fund Wicks’ corn breeding program, which includes yellow as well as white corn lines.

“We have varieties that are ready to go for South Dakota if someone wants to put them in production.”

White corn yields are close to those of yellow corn, perhaps yielding a few bushels per acre less. But historically, white corn premiums have made up for the yield difference, he adds. ♦
—Lance Nixon



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